COMUNICAÇÃO TÉCNICA

Nº 178480

Estratégias, desenvolvimentos e oportunidades para a produção de SAF – Sustainable Aviation Fuel

Vittor Rodrigues Santos Alves

Palestra apresentado apresentada na disciplina de Seminários em Biotecnologia Programa de Pós-Graduação Interunidades em Biotecnologia - Universidade de São Paulo. 14 slides

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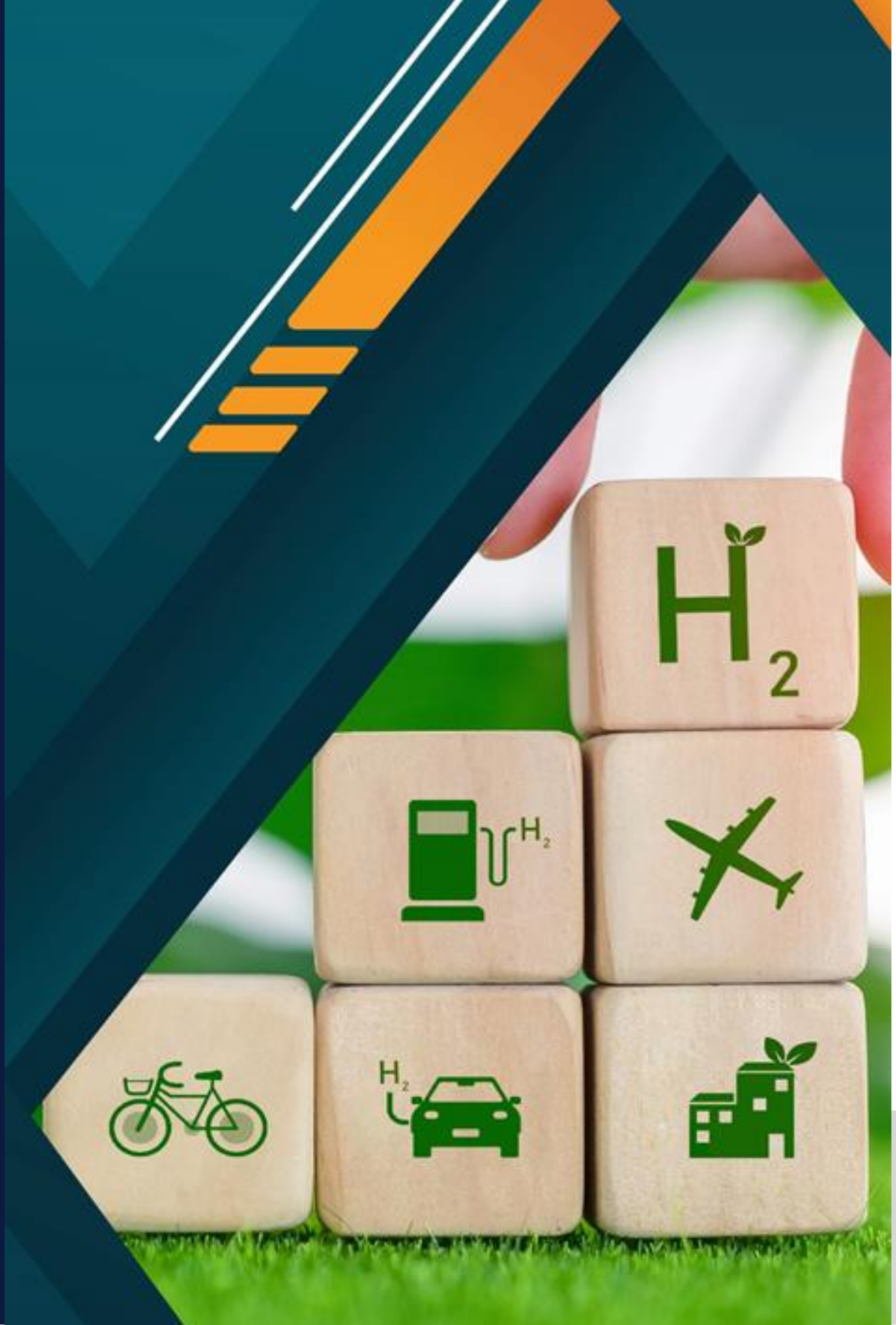

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ESTRATÉGIAS, DESENVOLVIMENTOS E OPORTUNIDADES PARA A PRODUÇÃO DE SAF - SUSTAINABLE AVIATION FUEL

Energia e Bionanofatura – IPT

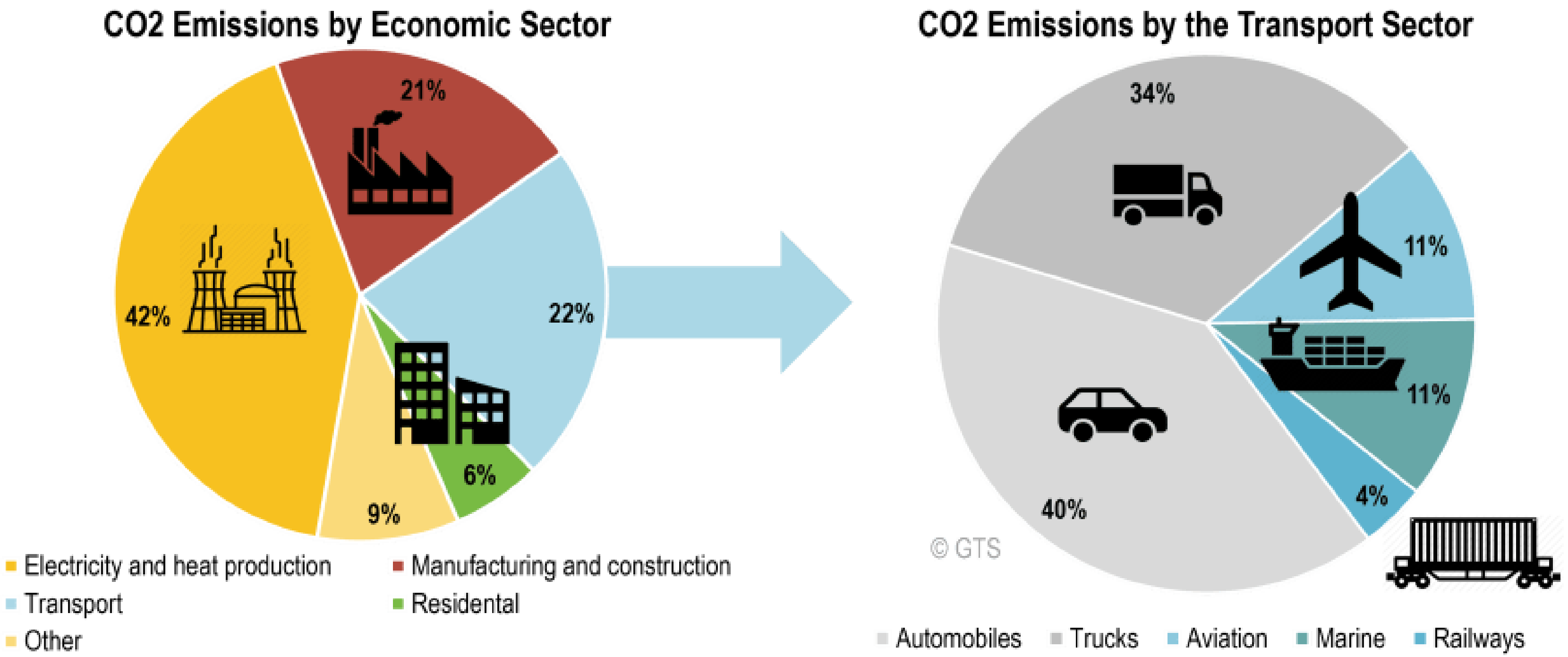
04.Abril.2024

SÃO PAULO GOVERNO DO ESTADO

1. INTRODUCTION

What is the problem on the view?

Figure - Global Greenhouse Gas Emissions by the Economic Sector and in the Transport Sector



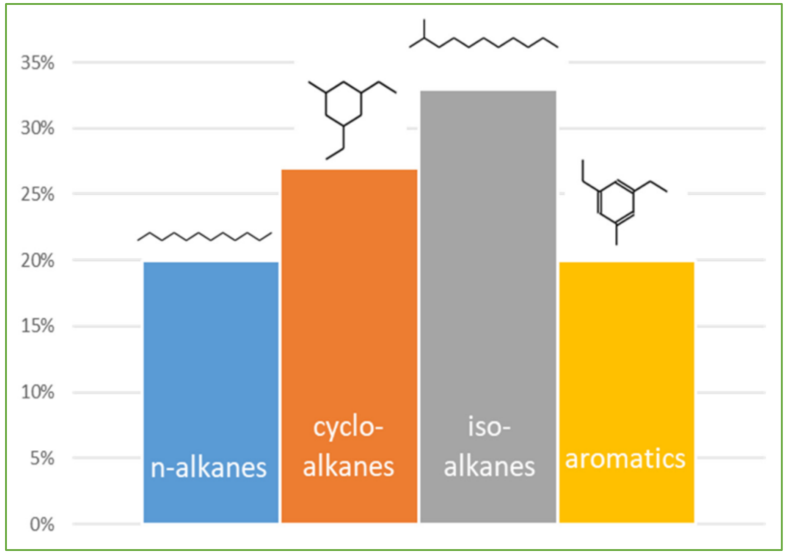
Source: IEA e IPCC (2014) - The Geography of Transport Systems – (https://transportgeography.org/)

1. INTRODUCTION

WHAT IS JET-FUEL?

- **Jet-A1** is the most widely used jet fuel in the world, including the US.
- Its high freezing point (-47 °C) makes it suitable for long flights when traveling in severe winter conditions.
- Aviation fuels have much stricter physical-chemical specifications (**ASTM D1655**-09) than road fuels.
- Jet A1 - has a chemical composition based on iso-alkanes and cyclo-alkanes

Chemical composition



Source: Díaz-Pérez and Serrano-Ruis, 2020

Fuel Properties

Fuel Propertie	Jet A	Jet A-1
Acidity, mg KOH/g	0.10 Max.	0.10 Max. (0.015 Max for Def. Stan 91-091)
Aromatics, Vol. %	25 Max.	25.0 Max.
Sulphur, mercaptan, Wt. %	0.003 Max.	0.0030 Max.
Sulphur, total, Wt. %	0.30 Max.	0.30 Max.
10% Distillation, ºC	205 Max.	205.0 Max.
Final Boiling Point, ºC	300 Max.	300.0 Max.
Distillation Residue, %	1.5 Max.	1.5 Max.
Distillation Loss, %	1.5 Max.	1.5 Max.
Flash Point, ºC	38 Min.	38.0 Min.
Density @ 15ºC, kg/m3	775 to 840	775.0 to 840.0
Freeze Point, ºC	-40 Max	-47.0 Max
Viscosity @ -20ºC, mm/s	8.0 Max.	8.000 Max.
Net Heat of Combustion, MJ/kg	42.8 Min.	42.80 Min.

1. INTRODUCTION

Chemical definitions of Jet-A1

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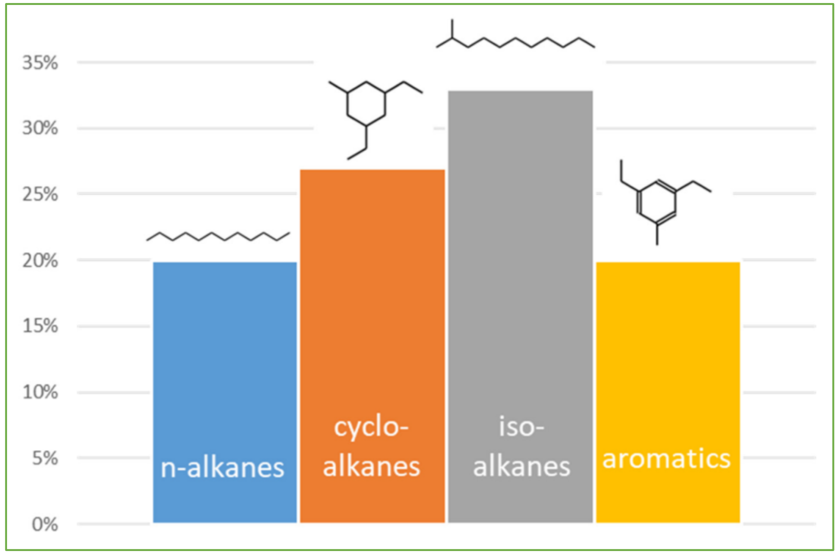

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2. PATHWAYS

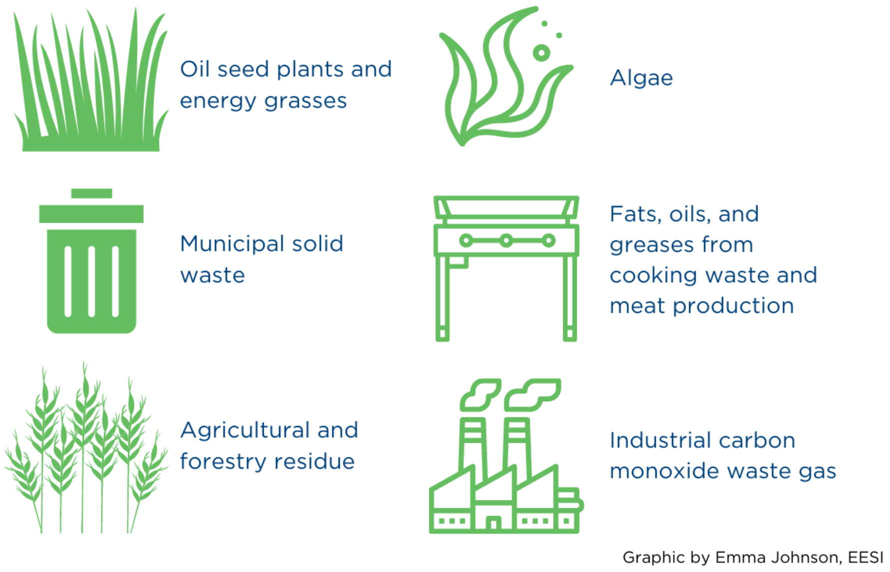
SAF *pathways*

How the possible pathways to SAF in the Brazilian scenário?

FEEDSTOCK	*SAF PRODUCTION*					Products
	Gasification with Fischer Tropsch					
✓ Lignin E2G, SCW, cellulignin and others	Biomass	Pre-treatment	Gasification	Fischer-Tropsch synthesis	Refining/ Separation	**SPK** **Naphta** **Diesel** **Eletricity**
	Alcohol to Jet (ATJ)					
✓ Ethanol (CH_3CH_2OH)	Alcohol	Dehydrataion	Oligomerization	Distillation	Hydrogenation	**SPK** **Ethylene** **Electricity** **Distillers's dried grains with solubles**
	Direct Sugars to Hydrocarbons (DSCH)					
✓ Sugars (C5 and C6)	Sugars	Hydrolisis/ Fermentation	FARNESENE	Purification	Hydrogenation	**SiPK** **Yeast** **Distillers's dried grains** **Eletricity**
	Pyrolysis to Jet					
✓ Lignin E2G, SCW, cellulignin and others	Biomass	Pre-treatment	Fast Pyrolysis	Hydroprocessing	Separation	**SPK** **Naphta** **Diesel** **Eletricity**
	Hydroprocessed esters and fatty acids (HEFA)					
✓ Vegetable and waste oils, animal fats	Oil Extration	Hydrotreatment Decarboxylation	Isomeratization	Selective Hydrocracking	Separation	**SPK** **Naphta, Diesel** **Propane** **LPG** **Protein meal**

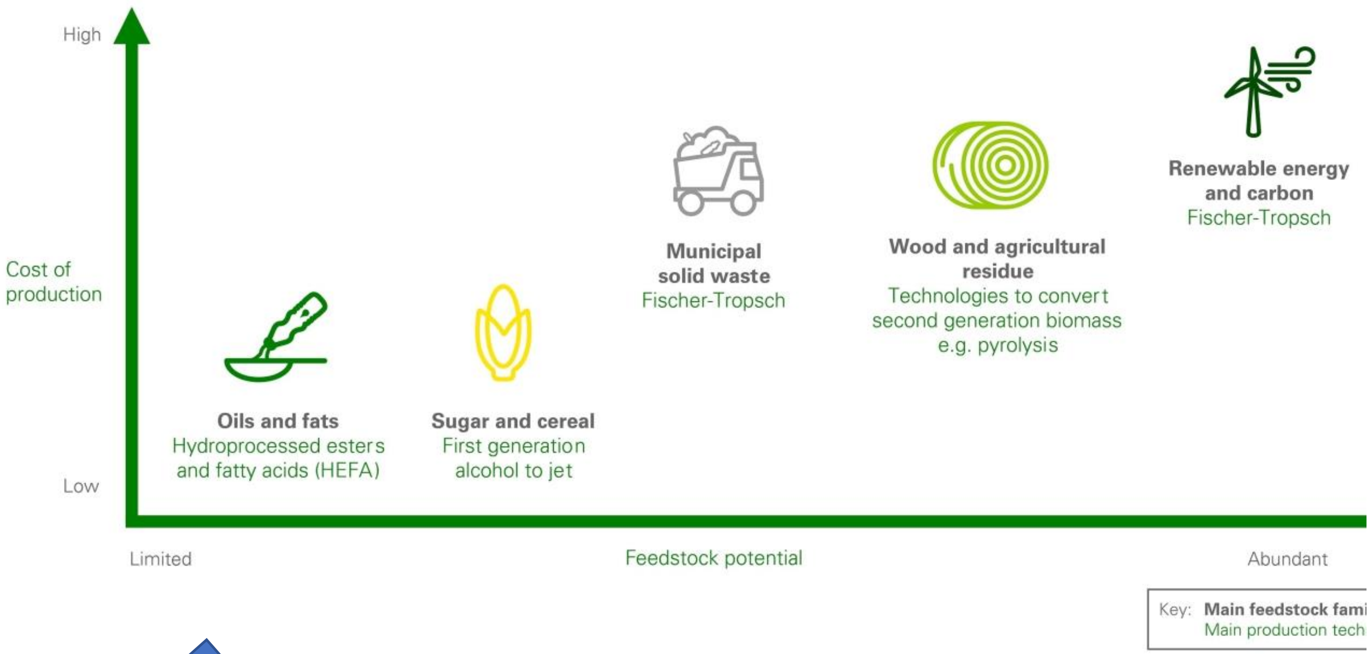
2. FEEDSTOCK

Figure – Feedstock suitable for SAF production



Source: eesi.org

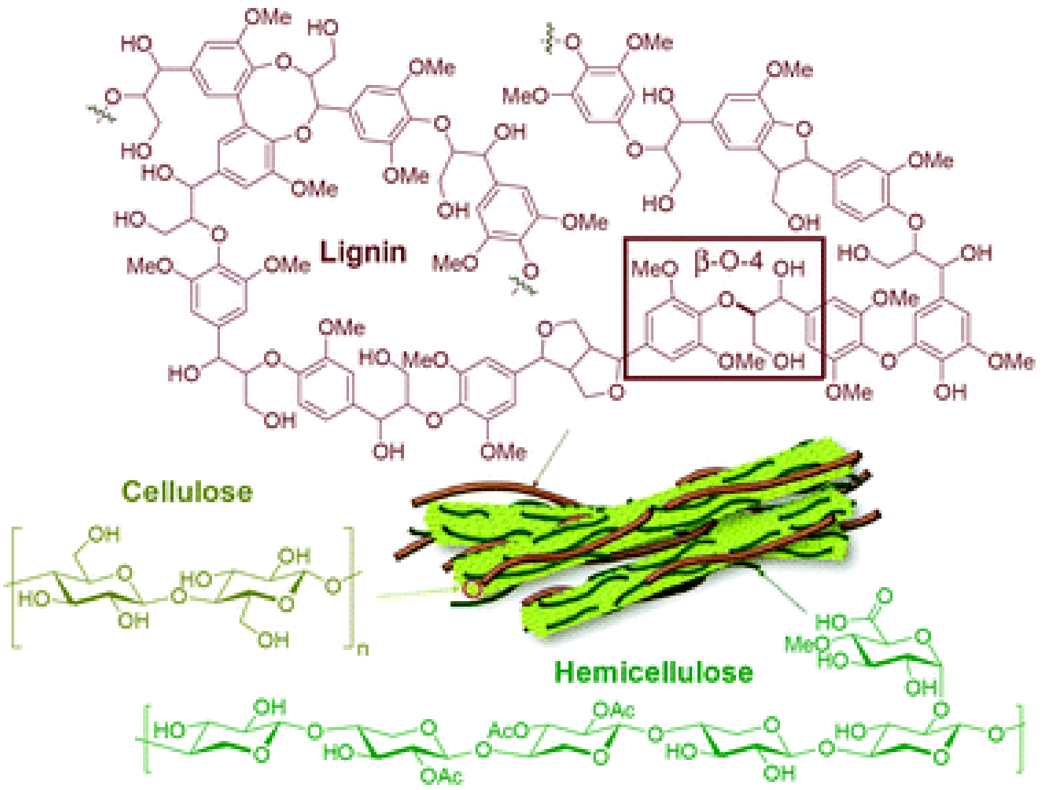
Figure – Feedstock families and its constraints



Source: Air bp. (timesaerospace.aero)

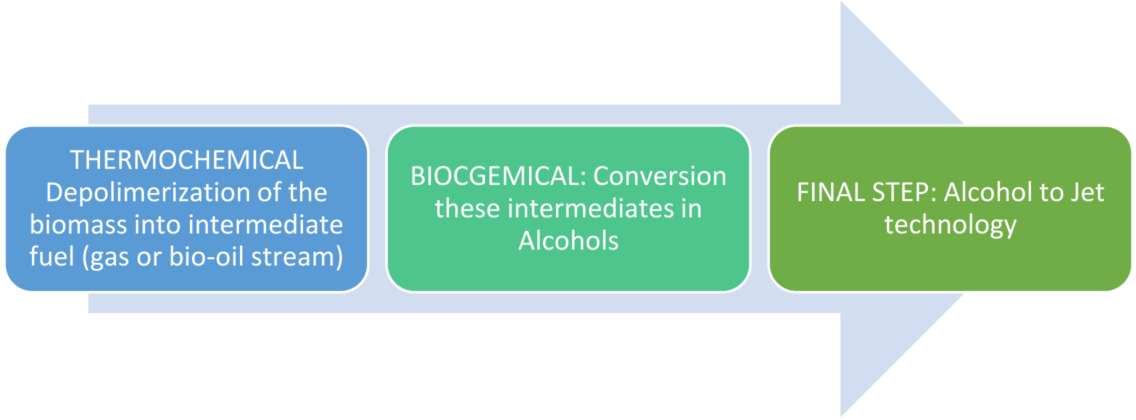
3. HYBRID ROUTES FOR SAF PRODUCTION

As the best way to take advantage of the entire lignocellulosic chain (Holocellulose + lignin) in liquid fuels?



One possible solution:

THERMOCHEMICAL + BIOCHEMICAL



Examples

1) Fermentation of pyrolytic sugars

2) Gas fermentation (FT or Fermentation)

3.1 EXAMPLE 1 – FERMENTATION OF PYROLYTIC SUGARS

BIOMASS FAST PYROLYSIS

LIGNOCELULOSIC BIOMASS OR ORGANICA WASTE

Thermochemical decomposition of organic matter in the absence of oxygen or with limited amounts of oxygen. This process occurs at high temperatures, generally between 400 - 600 °C at high heating rates

HEAT

Yield – 40 – 70% wt

BIO-OIL

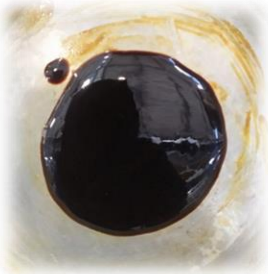
Yield – 10 – 30% wt

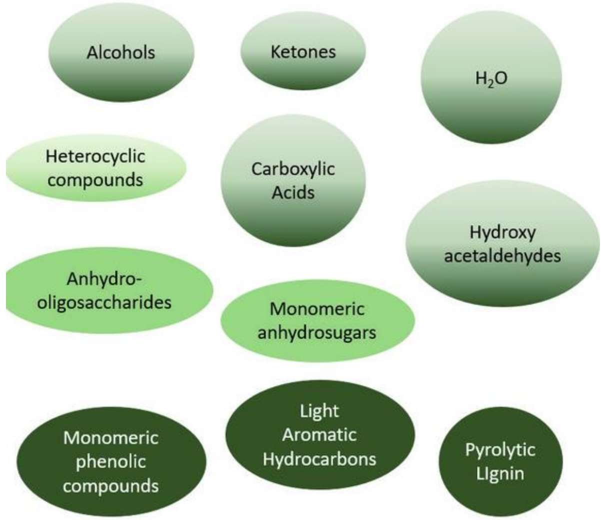
Biochar

Pyrolytic Gas

- Bio-oil is the main product?
- What is Bio-Oil?

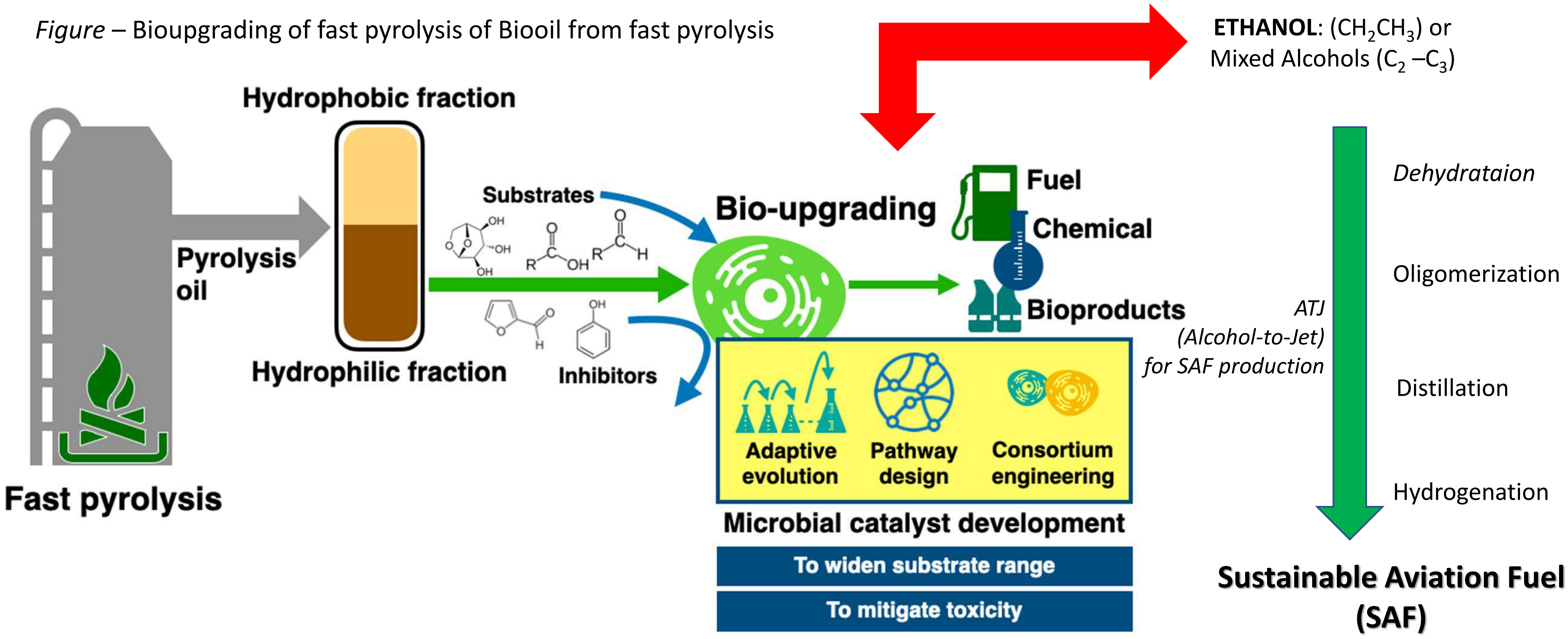
Figure – Bio-oil from Sugar Cane straw produced in IPT





3.1 EXAMPLE 1 – FERMENTATION OF PYROLYTIC SUGARS

Figure – Bioupgrading of fast pyrolysis of Biooil from fast pyrolysis

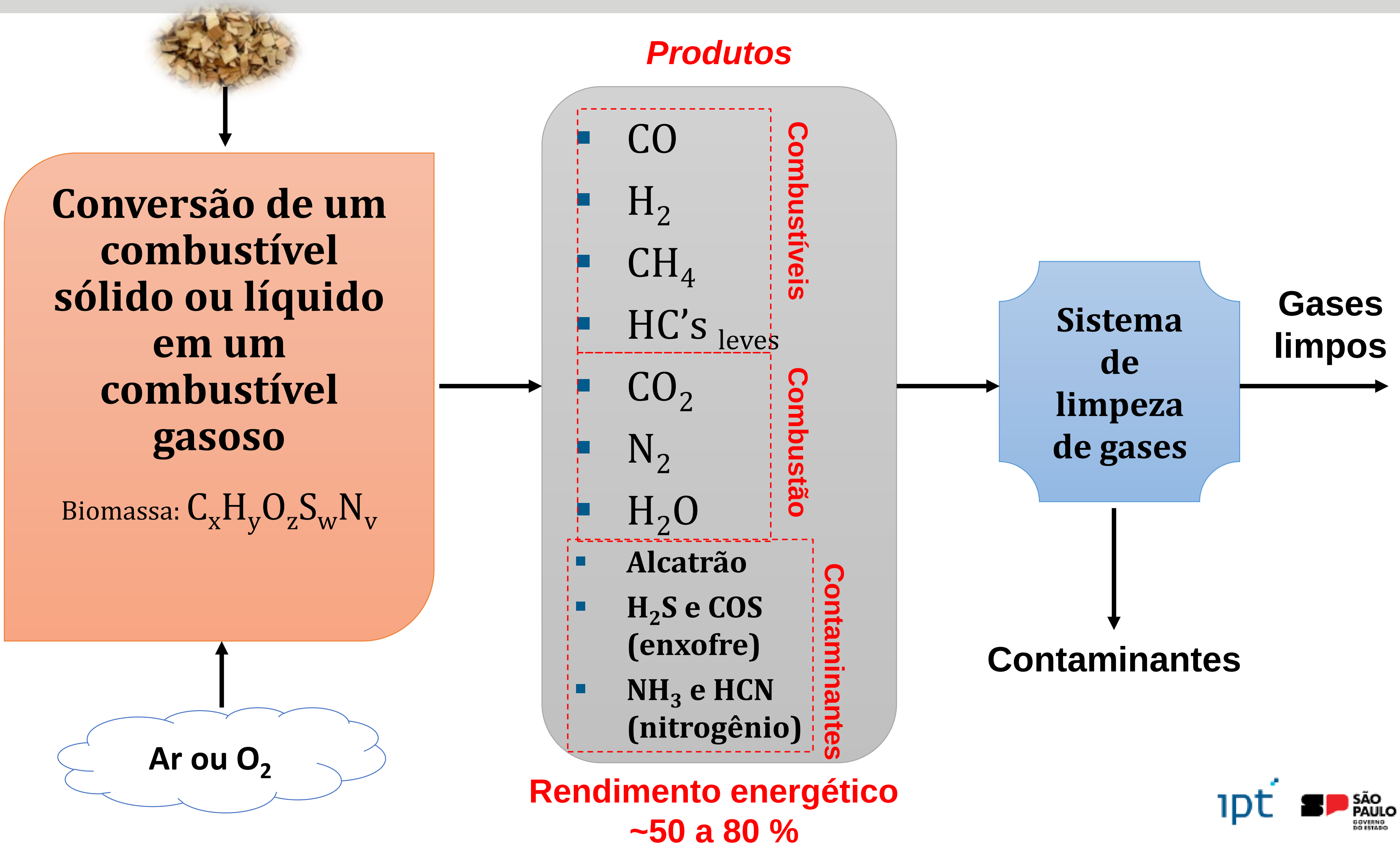


Sustainable Aviation Fuel (SAF)

Source: - Adapted from Ashoor et al. 2023

3.2 EXAMPLE 2 – BIOSYNGAS (FROM GASIFICATION) FOR SAF

What is Syngas? →
Its mixture of H_2+CO
that can be obtain
from biomass
gasification



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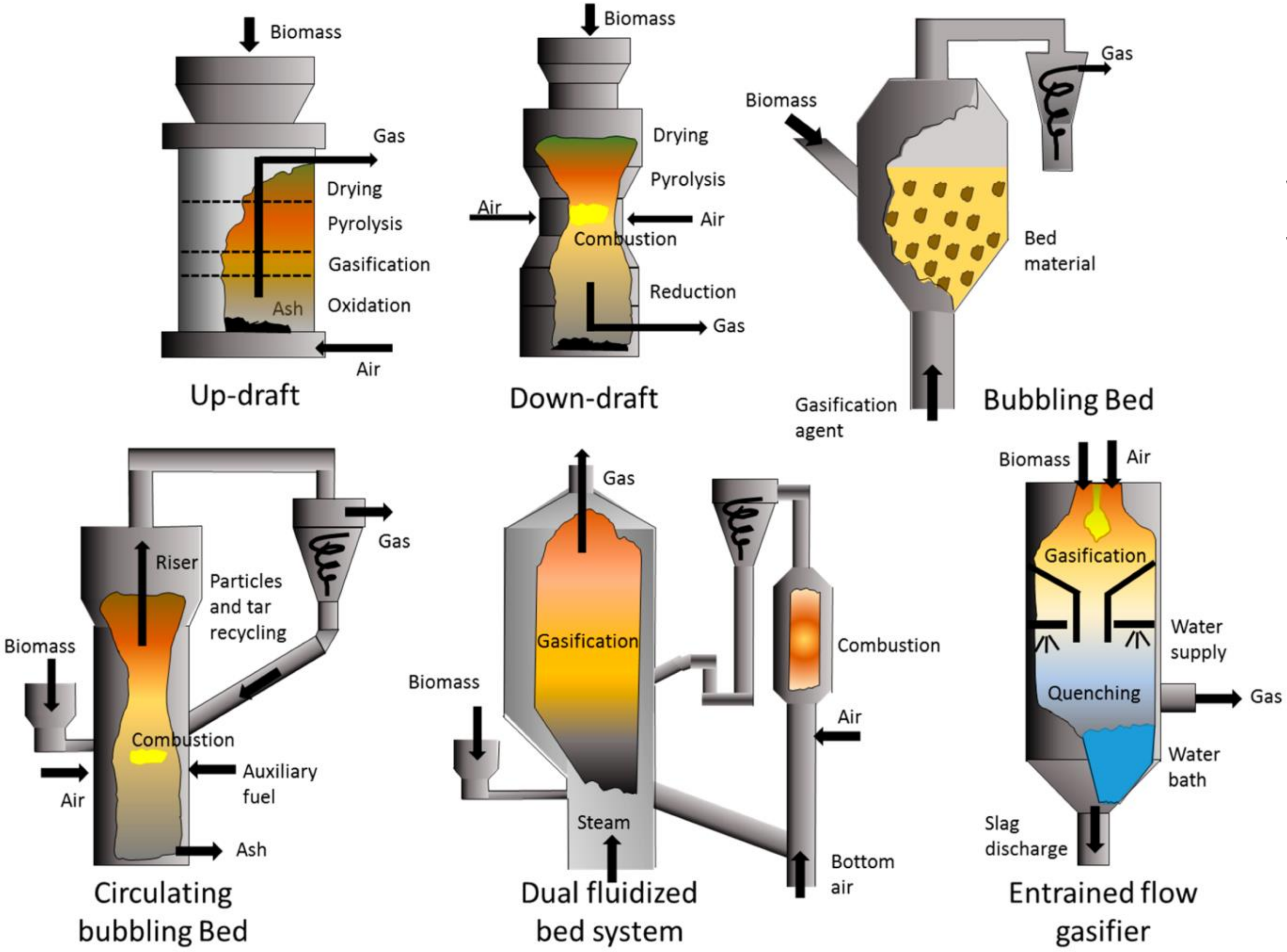


Choice depends:

Which is the most adequate scale

Which products are desired

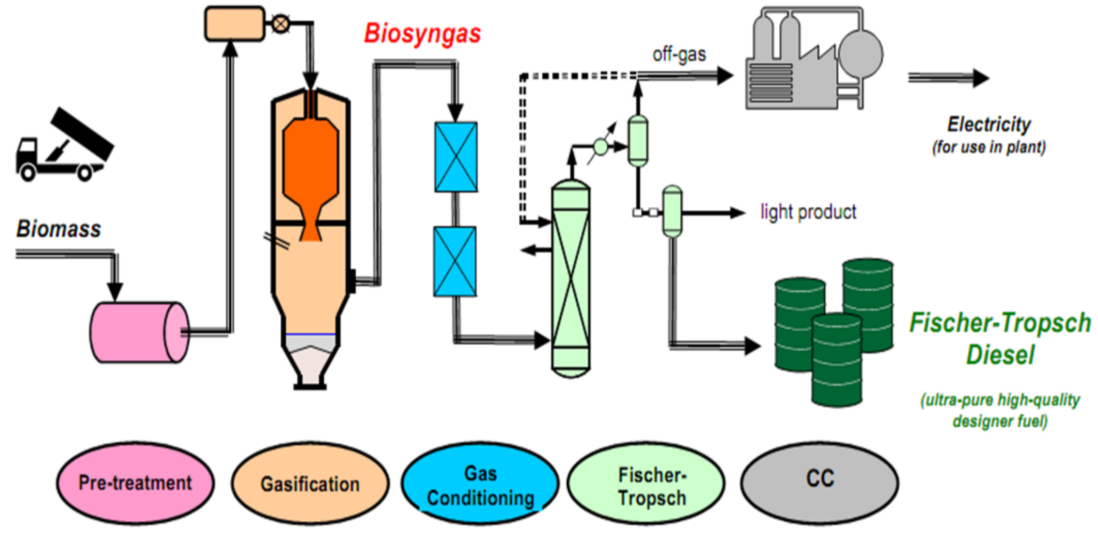
What to do with raw syngas from de biomass gasification?

3.2 EXAMPLE 2 – BIOSYNGAS (FROM GASIFICATION) FOR SAF

Cleaned biosyngas (H2 + CO **+/-** CO_2)

THERMOCHEMICAL – Fischer-Tropsch

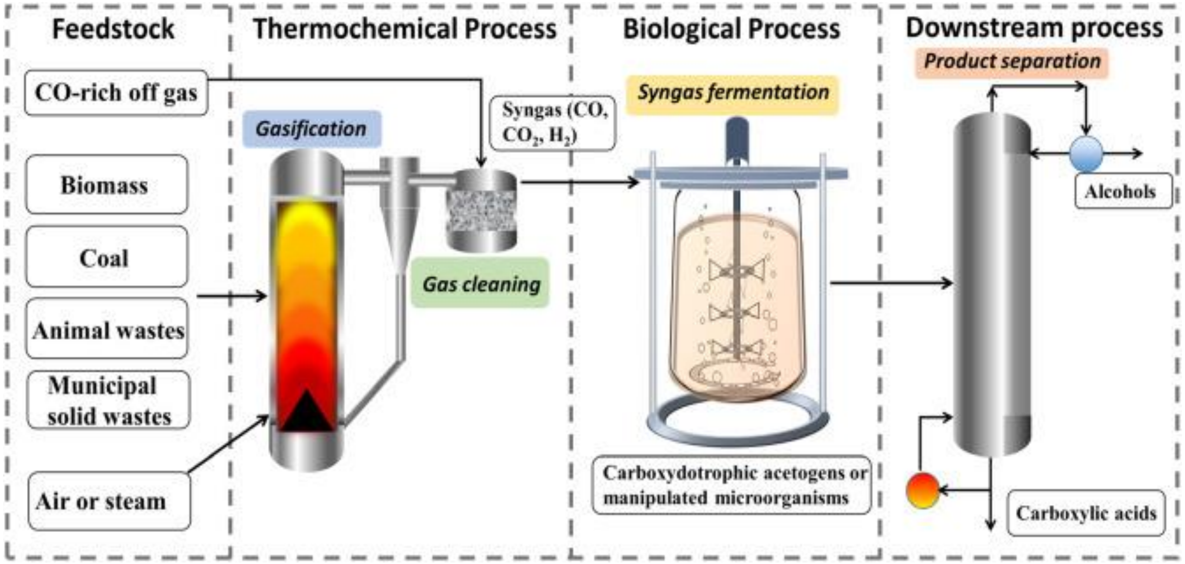
General Process Conditions: Fe or Co supported catalyst, 200 – 350°C, H2:CO = 2:1, FB or Slurry Reactor, GHSV =5000 NL/h.kg_{cat})



Schematic line-up of the integrated BTL plant.

BIOCHEMICAL – Fermentation to Alcohols

General Process Conditions: *Clostridium ljungdahlii* Strains, mesophilic range: 25 – 40°C, CSTR, Buble Collumn, Gas Lift etc)



Source: - Sun et al. 2023

4. REFERENCES AND RECOMMENDED TEXTS

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